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OPERATING EXPERIENCE WEEKLY SUMMARY

Office of Nuclear and Facility Safety

May 22 - May 28, 1998

Summary 98-21

Operating Experience Weekly Summary 98-21

May 22 through May 28, 1998

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EVENTS

1. ELECTRICIAN BURNED AT KANSAS CITY PLANT

On May 24, 1998, at the Kansas City Plant, an electrician was hospitalized with second- and third-degree burns to the face, neck, arms, and hand from electrical flash burns. He also sustained a concussion. The electrician is expected to receive surgery to graft skin on his arm because of the third-degree burns. He was performing preventive maintenance on a high voltage switch when an electrical arc occurred. An accident investigation team has been assembled to perform a Type B investigation of this event. OEAF engineers will follow the accident investigation and provide information as it becomes available. (ORPS Report ALO-KC-AS-KCP-1998-0010)

KEYWORDS: injury, Type B investigation, electrical safety

FUNCTIONAL AREAS: Electrical Maintenance, Industrial Safety

2. DRUM PRESSURIZATION

On May 8, 1998, at the Idaho National Engineering and Environmental Laboratory, a Waste Operations employee was opening a 55-gallon metal drum and the lid lifted forcefully because of internal pressurization. The lid brushed the face of the Waste Operations employee and hit the wall and ceiling of the cargo container in which the drums were stored. The pressurized drum contained dry, granular, depleted uranium oxides. Drum pressurization events have caused numerous similar near-miss occurrences throughout the DOE complex. These events can cause severe personal injury or result in environmental releases. (ORPS Report ID--LITC-SMC-1998-0004)

Investigators determined that samples were obtained from the drum in February 1998 without incident. The Waste Operations employee did not suspect that the drum would be pressurized because she was aware of the drum contents and saw no outward signs of drum pressurization (bulging). Investigators believe that water condensation inside the drum may have reacted with the depleted uranium oxides to generate gases. Radiological control technicians surveyed the area and determined that there was no spread of contamination. Workers replaced the drum lids but left the lids unsealed until corrective actions can be developed.

NFS has reported other drum pressurization events in several Weekly Summaries. Following are some examples.

- Weekly Summary 98-10 reported that an inspector at the Idaho National Engineering and Environmental Laboratory found two bulging drums stored in a locked Resource Conservation and Recovery Act-compliant portable storage unit. Investigators believed the effect of anaerobiosis on septic wastes stored in the drums generated gasses and pressurized the drums. A worker dressed in personal protective equipment, including a respirator, vented both drums by placing a specially-designed net over the drums, loosening the lid ring bolts, and tapping the lids until gas could be heard escaping. (ORPS Report ID--LITC-CFA-1998-0002)

- Weekly Summary 97-03 reported that a hazardous waste worker was loosening a bolt on a 110-gallon drum ring at the Fernald Environmental Management Project when the lid blew off, striking the ceiling 14 feet above the worker and coming to rest on the floor 3 feet away. (ORPS Report OH-FN-FDF-FEMP-197-0003)

- Weekly Summary 96-42 reported on two events involving lids that were blown off pressurized drums when the locking rings were loosened. At the Paducah Plant, a waste sampler loosened a locking ring with a hammer; and the ring, the lid, and some contents blew out of the drum. At the Hanford Tank Farms, an operator loosened and moved the locking ring on a drum, and the lid flew 2 to 3 feet into the air and fell back on the drum. There was no radiological contamination or injuries in either occurrence. (ORPS Reports ORO--LMES-PGDPENVRES-1996-0002 and RL--PHMC-TANKFARM-1996-0076)

These events underscore the importance of recognizing that many of the materials typically stored in drums generate gasses and may pressurize the drum. Drum selection should take into account the possibility of gas generation and should incorporate a self-venting feature or provide for convenient manual venting if pressurization is suspected. Trained personnel should use procedures and equipment specifically developed for the safe venting of drums. These events also underscore the importance of suspecting that any drum may be pressurized and knowing the hazards that a pressurized drum presents to workers and the environment.

When drum pressurization is suspected, facility managers have a number of options to consider when planning activities to relieve the pressure inside the drums. Drum lid restraining devices may be as simple as cargo net webbing secured over the drum. A commercially available example of a web type of lid restraining device is the Drum Web 5585 manufactured by EET Corporation. Their URL is www.eetcorp.com. Drum venting devices may be as simple as a non-sparking spike at the end of a backhoe used to puncture the drum lid. When a hazardous release can be expected, the venting should be performed in a high efficiency particulate air filtered enclosure. Figure 1 shows a commercially available drum lid restraining device. Figure 2 shows a commercially available device to remotely vent pressurized drums. Figure 3 shows an enclosed drum venting system developed by the Los Alamos National Laboratory.

Figure 2-1. Drum Lid Restraining Device (Courtesy Machine Kinetics Corporation)[1]

Figure 2-2. Remotely Operated Drum Venting System (Courtesy Americlean, Incorporated)[2]

Figure 2-3. Drum Venting System (Courtesy Los Alamos National Laboratory)[3]

1 Additional information is available at productivity@machinekinetics.com.

2 Americlean Model 9500 is shown. Additional information is available at URL http://www.americlean-inc.com.

3 Additional information is available at URL http://www-emtd.lanl.gov/TD/WasteCharacterization/DrumVenting.html.

Reference to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply endorsement, recommendation, or favoring by the United States Government. End users and purchasing organizations are responsible for determining the suitability of methods and available products. It is incumbent upon these organizations to research all available products, perform make-versus-buy analyses, procure equipment, train personnel, and develop work plans based on anticipated hazards and available safety equipment.

In February 1993, NFS issued DOE/NS-0013, Safety Notice 93-1, "Fire, Explosion, and High-Pressure Hazards Associated with Waste Drums and Containers." This notice describes lessons learned on safe storage and handling of waste containers and drums. The notice specifically discusses handling, storing, venting, and opening containers suspected of being pressurized or containing flammable vapors. Safety Notice 93-1 can be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. Safety Notices are also available on the Operating Experience Analysis and Feedback Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html.

KEYWORDS: pressurized drum, safety

FUNCTIONAL AREAS: industrial safety, materials handling/storage

3. WASTE SAMPLE SHIPMENT VIOLATION

On May 15, 1998, at Lawrence Berkeley National Laboratory, site analytical laboratory personnel confirmed that a mixed waste sample shipment containing approximately 10 microcuries of americium and plutonium violated site procedures. The samples were shipped to an off-site analytical services contractor as exempt quantities, but should have been shipped as radioactive material. The facility manager suspended off-site shipments by Waste Management personnel until an investigation is completed. Failure to follow procedures resulted in an improper shipment of radioactive material and may have violated Department of Transportation hazardous material regulations. (ORPS Report SAN--LBL-EHS-1998-0002)

Investigators determined that site procedures require any shipment suspected of containing mixed waste to be sent to the site Radiation Protection Group. Mixed waste is waste that contains both radioactive and hazardous components. Radiation Protection Group personnel are required by procedure to sample the waste, analyze the sample results, and appropriately label the samples for shipment. However, Waste Management personnel violated site procedures because they did not send the suspected mixed waste samples to the Radiation Protection Group; instead, they shipped them directly to an analytical services contractor. Investigators reported that the contractor noticed three conflicting descriptions regarding the sample contents, so they analyzed them. When the contractor determined that the radioactivity level exceeded their license requirements, they returned the samples to the Radiation Protection Group. When the Radiation Protection Group received the waste samples, they noticed the shipping error and realized they had not made the shipment.

The facility manager held a fact-finding meeting on this event. Attendees learned that Waste Management personnel had made earlier shipments without sending the waste samples to the Radiation Protection Group for characterization. They also learned that the Radiation Protection Group had not previously questioned why they were receiving contractor shipments that they had not originally sent. The facility manager continues to investigate this event and will determine if Department of Transportation hazardous material regulations were violated. Corrective actions will be developed upon completion of the investigation.

NFS has reported improper radiological shipments in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-43 reported that Los Alamos National Laboratory Accelerator Complex facility shippers sent seven vacuum pumps to an off-site company for maintenance, and three of the pumps were internally contaminated. The three pumps contained residual oil contaminated with up to 6 µCi per liter of tritium, which is equivalent to 13 million dpm. The off-site company did not know the pumps were contaminated and did not have the controls, procedures, and radiological support to work on contaminated equipment. (ORPS Report ALO-LA-LANL-ACCCOMPLEX-1997-0014)

- Weekly Summary 96-17 reported that regulators from the State of Tennessee suspended radioactive shipments from the Savannah River Site to a commercial vendor near Oak Ridge. Regulators took action because a shipment from the Tritium Facility at the Savannah River Site contained more radioactivity than listed on shipping papers. The commercial vendor waste handlers discovered the discrepancy when off-gas stack alarms sounded as they started to process and shred the tritiated waste. The handlers were exposed to minimal radiation, but the tritium release through the stack was 4.5 curies, which is 24 times the daily limit allowed by state regulations. (ORPS Report SR--WSRC-TRIT-1996-0009)

- Weekly Summary 96-12 reported that a Los Alamos National Laboratory radiological control technician dismantled, re-assembled, and shipped a cesium-137 source over public roads in violation of procedures and Department of Transportation requirements. The technician measured 17 mrem/hr in a survey before dismantling the instrument. However, receiving radiological control technicians measured 140 mrem/hr at 30 cm outside the container and 660 mrem/hr on contact with the source. (ORPS Report ALO-LA-LANL-WASTEMGT-1996-0001)

OEAF engineers searched the ORPS database for procedure and transportation violations that resulted in the violation of Department of Transportation requirements from January 1990 to present. We found 110 procedure and transportation events of which 20 (18 percent) resulted in violating Department of Transportation requirements.[4]

These events illustrate the importance of performing proper waste characterization. Improper waste classification or labeling could lead to radiation exposures to workers or the public or the spread of contamination. Personnel who receive improperly classified packages can be unnecessarily exposed to the hazardous contents and may be unable to make a correct selection of personnel protective equipment if they discover damaged packages. Facility personnel who ship radioactive material should review the following to ensure transportation requirements are met.

- DOE 0 460.1A, *Packaging and Transportation Safety*, establishes safety requirements for packaging and transporting off-site shipments and for on-site transfer of hazardous materials. Hazardous material shipments are required to be

[4] OEAF engineers searched the ORPS database using the graphical user interface for reports with a nature of occurrence code of “06” (transportation) AND [nature of occurrence code of “01F” (violation or inadequate procedures) OR a direct cause, contributing cause, or root cause of “2A” (defective or inadequate procedure) AND “2B” (lack of procedure)] AND narrative containing <CASE><WORD>DOT OR “Department of Transportation” from January 1990 to present and found 110 events. OEAF engineers also searched the ORPS database for reports with a nature of occurrence code of “06” (transportation) AND nature of occurrence code of “01F” (violation or inadequate procedures) AND narrative containing <CASE><WORD>DOT OR “Department of Transportation” from January 1990 to present and found 20 events.

in compliance with the Department of Transportation hazardous materials regulations in 49 CFR 106-199 and the applicable tribal, state, and local regulations not pre-empted by the Department of Transportation.

- DOE 0 460.2, *Departmental Materials Transportation and Packaging Management*, establishes DOE policies and requirements to supplement applicable laws, rules, regulations, and other DOE orders for materials transportation and packaging operations.

- DOE/EH-0256T, *U.S. Department of Energy Radiological Control Manual*, provides clear direction on the marking, monitoring, and control of radioactive materials. Chapter 4, “Release and Transportation of Radioactive Material,” provides guidance for releasing radioactive material from controlled and uncontrolled areas and for transporting it off-site. Section 423, “Transportation of Radioactive Material,” states that off-site shipments of radioactive material, including subcontractors' handling of off-site shipments, shall be controlled and conducted in accordance with the Radiological Control Manual and applicable Federal, state and local regulations.

KEYWORDS: shipping, transportation, hazardous waste

FUNCTIONAL AREAS: Transportation, Materials Handling/Storage, Radiation Protection

4. WORKERS BYPASS MAN-LIFT SAFETY INTERLOCK

On May 14, 1998, at the Los Alamos National Laboratory High Explosives Machining and Pressing Facilities, a Facility Management employee observed a subcontractor fitter working at an elevated height using a man-lift that did not have the outriggers installed. He also observed that someone had inserted metal blocks into the outrigger ports to bypass the safety interlocks. A team leader stopped the work, removed the man-lift key, and notified the project supervisor and the subcontractor’s safety engineer. Bypassing designed safety features increases the likelihood of an accident and can result in equipment damage, personnel injuries, or death. (ORPS Report ALO-LA-LANL-HEMACHPRES-1998-0006)

Facility management procured the man-lift (classified as a manually propelled elevating aerial platform by OSHA) for use by various craft workers at the facility. The man-lift, as shown in Figure 4-1, is designed for one worker, who occupies the platform and controls its movement. It is equipped with four ports designed for the insertion of outrigger beams (see Figure 4-2). Each port has an interlock switch and an indicator light. When an outrigger beam is inserted into a port, the switch is closed, and the indicator light illuminates for that port. All four switches must be closed in order to operate the man-lift. Investigators determined that the metal blocks that were inserted into the outrigger ports to bypass the safety interlocks were not standard equipment.

Figure 4-1. Portable Personnel Lift (Courtesy UpRight, Incorporated)[5]

Figure 4-2. Portable Personnel Lift Outrigger Port (Courtesy Los Alamos National Laboratory)

The facility manager held a critique. Attendees determined that the outriggers were not delivered to the work site with the man-lift. They also determined that the blocks the fitters used to override the interlocks were delivered to the work site along with the man-lift and that the man-lift had probably been operated with the interlocks bypassed on other occasions. Attendees determined that the fitters had attended man-lift operation training and knew that using the man-lift without the outriggers installed was prohibited. Investigators also determined that stickers

[5] The UpRight, Incorporated, Portable Personnel Lift is shown. Additional information is available at URL http://www.upright.com.

near each outrigger port and the operating manual stored on the man-lift warn against operating the man-lift without its outriggers installed. They determined that the fitter had been working with the platform about 6 feet above the floor and that the platform for this class of man-lift can be raised to heights exceeding 25 feet. The investigation is continuing and corrective actions will be developed based on investigation results.

NFS has reported events about bypassing interlocks in numerous Weekly Summaries. Facility personnel have also reported several similar events to ORPS. Following are some examples.

- Weekly Summary 97-23 reported that a 30-ton mobile, hydraulic crane used to lift a 4,600-pound steel trench box tipped, and the boom landed on a 10-foot mound of dirt at the Hanford Tank Farms. The crane came to rest against the mound at a 45-degree angle. The crane operator and an assisting flagman were not injured. Investigators determined that the crane operator failed to extend all four outriggers as required for this type of lift. (RL--PHMC-TANKFARM-1997-0048)

- Weekly Summary 96-07 reported that a Sandia National Laboratory technician was shocked when his hand contacted a tester chassis energized to 6 kv. Investigators determined that an interlock bypass from testing conducted the previous day had been left in place and allowed the chassis to become energized. (ORPS Report ALO-AO-SNL-1000-1996-0002)

- On July 27, 1994, facility personnel at the Hanford Energy Research Programs Facility reported that a paper clip was used to bypass an interlock switch for a Class 3B laser. Investigators determined that a researcher bypassed the interlock during laser optimization. There were no personnel injuries and no equipment damage. (ORPS Report RL--PNNL-PNNLBOPER-1994-0037)

- On October 20, 1993, personnel at Lawrence Livermore National Laboratory reported that workers operated an x-ray machine in the open beam mode with an interlock bypassed. Investigators determined that the workers used an aluminum block to depress the interlock micro-switch so that the machine could be operated with the safety enclosure open. (ORPS Report SAN--LLNL-LLNL-1993-0070)

- On June 28, 1991, personnel at Lawrence Livermore National Laboratory reported that a worker's hands were exposed to x-rays when he intentionally bypassed interlocks to accommodate a large part in a sample holder. (ORPS Report SAN--LLNL-LLNL-1991-1020)

These events illustrate the hazards caused by failing to operate equipment according to approved methods or by defeating equipment safety features. Operators of lifting equipment, including elevating and rotating work platforms, must be qualified and knowledgeable about how to properly set outriggers and other features designed to stabilize the equipment. Operators must ensure that all safety requirements are met and should request assistance from the appropriate manager when an operation appears to be unsafe.

Equipment operators, supervisors, and facility managers should ensure that procedures and equipment safety features are used when operating equipment. Equipment operators should be trained on the safe handling of equipment, the specific safety features of the equipment, and the operating limitations of equipment. Following are some references that provide guidance on safe equipment handling.

OSHA 20 CFR 1910.67, subpart F, *Powered Platforms, Manlifts, and Vehicle-Mounted Work Platforms*, section (c)(2)(vi), states that when outriggers are used they "shall be positioned on pads or a solid surface." DOE-STD-1090-96, Revision 1, *Hoisting and Rigging*, discusses safe practices for operating lifting equipment. Section 3.4 states that procedures should reference applicable documents, such as vendor manuals, and that warnings, cautions, and operating limits should be highlighted. Sections 4.2 and 15.5.2.7 state that cranes with outriggers shall have the outriggers fully extended and blocked. Sections 4.4 and 15.5.2.7 discuss the design and use of personnel platforms. Facility managers should review these references to ensure that facility equipment operation is in compliance with the standards.

KEYWORDS: interlock, man lift, personnel safety

FUNCTIONAL AREAS: Industrial Safety, Construction

5. WORKER SUFFERS FROM HEAT STRESS

On May 19, 1998, at the Argonne National Laboratory-East, a Waste Management mechanic became ill after leaving a decontamination work area. The work area temperature was 90 degrees Fahrenheit, and the mechanic was wearing double Tyvek® coveralls and a supplied air respirator. Facility workers called 911; paramedics responded and transported the mechanic to a local hospital. The mechanic was released from the hospital and reported back to work on the same day. Physicians diagnosed hypoglycemia and heat cramps. Heat cramps can result in painful spasms of the muscles. More severe forms of heat stress can result in permanent brain damage or death. (ORPS Report CH-AA-ANLE-ANLEEMO-1998-0004)

Investigators determined that work planners did not perform a heat stress survey for the work performed. Investigators also calculated the stay-time for the work conditions. Using the American Council of Governmental Industrial Hygienists (ACGIH) methodology, they determined that the worker exceeded the calculated stay time by approximately one hour.

NFS reported a similar heat stress-related event in Weekly Summary 98-08. A maintenance fitter at the Idaho National Environmental Engineering Laboratory was contaminated after he removed his acid suit in a high contamination area. Investigators determined that the fitter removed his acid suit during the job because of heat-stress concerns. This allowed contamination to wick through his perspiration-soaked coveralls and contact his skin. Investigators also determined that exceeding heat stress stay-times contributed to this event. (ORPS Report ID--LITC-WASTEMNGT-1997-0027)

These events illustrate the need to consider all hazards when determining worker protection requirements for a job performed in a hot area. Workers could be exposed to increased contamination hazards while wearing minimum protective clothing to reduce potential heat stress. Heat stress stay-times protect workers from the physical effects of exposure to extreme temperatures. Stay-times are maximum limits that require an individual to leave a high-temperature environment, even though the individual may feel capable of continuing work. The physical effects of heat stress often give little warning to the individual; therefore, limits must be adhered so that worker protection is ensured.

Four environmental factors affect the amount of heat stress a worker faces in a hot work area: temperature; humidity; radiant heat (such as from the sun or a furnace); and air velocity. Perhaps most important to the level of stress an individual faces are personal characteristics such as age, weight, fitness, medical condition, and acclimatization to the heat.

The following are heat stress disorders, listed from most to least severe.

- Heat stroke is the most severe form of heat stress. This occurs when the body's system of temperature regulation fails and the temperature rises to critical levels. The primary signs of heat stroke are confusion; irrational behavior; loss of consciousness; convulsions; lack of sweating; hot, dry skin; and an abnormally high body temperature. This condition is caused by a combination of variable factors, and its occurrence is difficult to predict.

- Heat exhaustion results from loss of fluid through sweating when a worker has failed to drink enough fluids or take in enough salt or both. The worker still sweats but experiences extreme weakness or fatigue, giddiness, nausea, or headache.

- Heat cramps are painful spasms of the muscles, caused when workers drink large quantities of water but fail to replace their bodies' salt loss. Tired muscles are usually the ones most susceptible to cramps.

- Fainting (heat syncope) may be a problem for the worker unacclimatized to a hot environment who simply stands still in the heat.

- Heat rash, also known as prickly heat, may occur in hot and humid environments where sweat is not easily removed from the surface of the skin by evaporation. When extensive or complicated by infection, heat rash can be so uncomfortable that it inhibits sleep, impedes a worker's performance, or even results in temporary total disability.

The American Council of Governmental Industrial Hygienists establishes threshold limit values for work in hot environments. Threshold limit values are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 100.4 degrees Fahrenheit. In some cases, work planners may want to equip workers in hot environments with portable heat stress monitors. These may be useful when heat conditions are difficult to predict and remote monitoring of worker health is desired. The Los Alamos National Laboratory developed a telemetric heat stress monitor that is commercially available. More information on this device can be found at URL http://146.138.63.109/docs/synergy/96spr/sec16.html.

Facility managers should review procedures for preparing work packages to ensure that the reviews are performed correctly and that high-heat conditions are identified. They should also ensure that all work-related hazards are evaluated before work begins to reduce worker exposure to hazards and to prevent injuries.

- DOE O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, states that the contractor must identify workplace hazards and evaluate the risk of associated worker injury or illness.

- DOE/EH-0256T, *Radiological Control Manual*, Table 3-1, provides guidelines for selecting the appropriate protective clothing. Chapter 3 of the manual provides guidance for proper personnel protective equipment and clothing. Chapter 5, Article 534, discusses heat stress considerations and states that supervisors should inform their personnel of heat stress precautions before beginning work on job assignments in hot environments.

- American Council of Governmental Industrial Hygienists, *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices,* is a yearly publication that establishes maximum stay times for work in hot environments.

- OSHA Technical Manual, section II, chapter 4, “Heat Stress,” provides discussions on causes, effects, and controls of heat stress.

- The *Hazard and Barrier Analysis Guide*, developed by OEAF, discusses barriers that control job-associated hazards, such as physical barriers, procedural or administrative barriers, or human action. The reliability of a barrier is determined by its ability to resist failure. Barriers can be imposed in series to provide defense-in-depth and to increase the margin of safety.

The OSHA Technical Manual is available at URL http://www.osha-slc-gov/TechMan_data/II_4.html. *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* may be ordered from The American Council of Governmental Industrial Hygienists at URL http://www.acgih.org. A copy of the *Hazard and Barrier Analysis Guide* is by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. A copy can also be found at URL http://tis.eh.doe.gov:80/web/oeaf/tools/hazbar.pdf.

KEYWORDS: heat stress, hazard analysis, personal protective equipment

FUNCTIONAL AREAS: Industrial Safety, Work Planning

6. TECHNICIAN RECEIVES SHOCK FROM AN ELECTRICAL ARC

On May 14, 1998, at Sandia National Laboratory, a technician received a shock when he opened a test cabinet, pointed to a spliced cable, and an arc traveled approximately 3 inches and contacted his finger. The technician believed he had heard an arc earlier when he was calibrating resistive voltage dividers, so he notified his project leader and they began troubleshooting the system. While they were troubleshooting, the technician observed another arc in the test cabinet. The technician and the project leader disconnected a pulse-forming network from a test tank by pushing a stop button because they believed this would de-energize the system. When the technician opened the test cabinet to point out a spliced cable that he believed was the cause of the arc, he was shocked. Medical personnel examined the technician and determined that he was not injured. Investigators determined that a cable modification created an unrecognized electrical hazard that could have caused serious injury. (ORPS Report ALO-KO-SNL-1000-1998-0003)

Investigators determined that calibration personnel had installed a temporary power supply in the system because of a malfunction in the normal power supply. After installation, calibration personnel realized that the temporary power supply cable connector did not fit properly, so they spliced it. Investigators also determined that the power supply was not de-energized when the technician opened the test cabinet. Investigators determined that the door interlocks that normally de-energized the power supply were not connected to the temporary power supply. They determined that it was supplying 27.5 kV at 15 milliamps to a test component when the technician heard the first arc. Investigators determined that pushing the stop button disconnected the pulse-forming network from the test tank, but did not de-energize the system. The facility manager continues to review this event to develop corrective actions. A site Electrical Safety Committee previously initiated a campaign to encourage site personnel to report all electric shock events and perform root cause analyses. The committee uses this information to discover and trend conditions that warrant corrective actions to improve electrical safety at Sandia.

NFS has reported on electrical shock events at Sandia in several Weekly Summaries. The following example discusses two of these events and indicates that a number of similar events have recently occurred at Sandia.

Weekly Summary 98-04 reported two events where personnel received electric shocks. On January 16, 1998, at the Tube Test Area, a technician received an electrical shock while replacing a test circuit. Technicians had installed the test circuit the previous day. They tested it, found a malfunctioning part, and decided to replace it. While removing the suspect part, one technician received a shock. On January 22, 1997, at the Sandia Lightning Simulator, a technician received an electrical shock while troubleshooting a trigger circuit on a Mini-Marx generator. The technician checked several system components, including capacitors, and determined that a component had not malfunctioned. When he began cleaning the support fixtures, he received a shock. Investigators determined that the procedures the technicians used did not provide detailed steps or instructions for the work being performed. The DOE facility representatives and the facility managers reviewed these events and determined that five similar events had occurred at the Laboratory over the last 2 years. (ORPS Reports ALO-KO-SNL-14000-1998-0001 and ALO-KO-SNL-9000-1998-0002) The facility managers also determined that employees involved in all five events were performing open test set-up work around high voltage that contained pulse-forming network capacitors. (ALO-KO-SNL-1000-1996-0002, ALO-KO-SNL-14000-1996-0004, ALO-KO-SNL-1000-1997-0002, ALO-KO-SNL-1000-1997-0005, ALO-KO-SNL-1000-1997-0008)

According to investigators, the following three issues were common to all of the previous Sandia events.

- Inadequate Procedures—The procedures were modified after each event to provide additional details to workers.

- Unknown Energy Status—Workers either did not know that the capacitors were charged, did not realize they were working with high voltage, did not have a complete understanding of the system limitations, or were confused by several workers making multiple equipment status decisions.

- Inadequate Work Planning—Investigators determined that workers assigned to the jobs were not adequately trained in three of the events; the job scope or design changed in two of the events; and work hazards during planning were not addressed in one of the events.

OEAF engineers reviewed selected occurrences from the ORPS database from October 1, 1990, through March 31, 1998, for reports that involved hazardous electrical occurrences and found 794 reports. We determined that each occurrence fell into at least one of the categories shown in Figure 6-1. We determined that short circuits, shocks, and damaged cables were the most prevalent types of hazardous electrical occurrences. Overheating and water-related events were determined to be the least prevalent types of hazardous electrical occurrences.

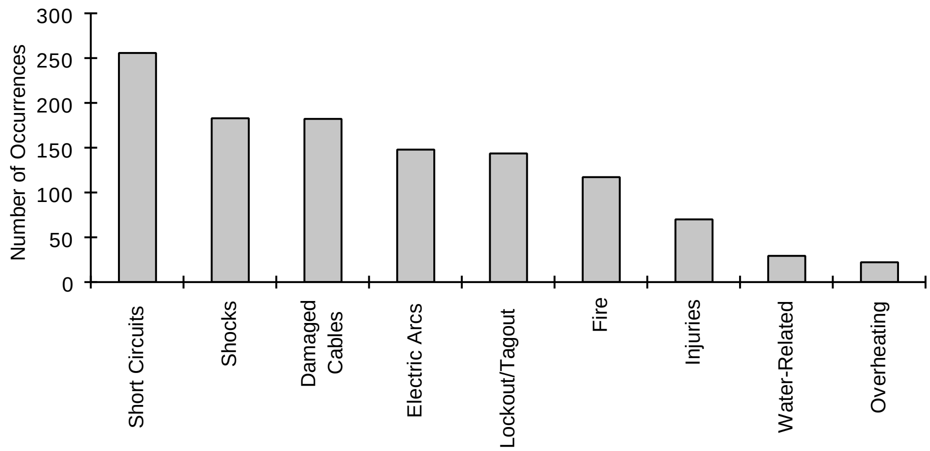

Figure 6-1. Types of Hazardous Electrical Occurrences[6]

These events illustrate the importance of practicing proper change control and configuration control when equipment modifications are performed. A good configuration control process requires modification testing to ensure that systems continue to perform as required and that safety hazards are not introduced. Testing the system before performing work could have prevented this event. Correct and current information must be translated into procedures and evaluated when modifications to systems or components are made. This guidance must be technically accurate, complete, and up-to-date and must be presented in a clear, concise, and consistent manner that minimizes human error.

Managers and supervisors in charge of job performance should ensure that hazards are identified and corrected. DOE facility managers should ensure that personnel understand the basics of work control practices and safety and health hazard analyses. Personnel in charge of system design changes should ensure that facility documentation, including procedures and drawings, is updated and accurate.

- DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities*, chapter VIII, “Control of Equipment and System Status,” states that DOE facilities are required to establish administrative control programs to handle configuration changes resulting from maintenance, modifications, and testing. Paragraph C.9, "Temporary Modifications," provides guidance on establishing administrative control systems for installation of temporary modifications.

- DOE/ID-10600, *Electrical Safety Guidelines*, prescribes electrical safety standards for DOE field offices and facilities. Included in the guidelines is information on training and qualifications, work practices, protective equipment, insulated tools, and recognition of electrical hazards. In July 1996, prompted by the recurrence of incidents across the DOE complex involving actual or potential electrical shock incidents, the Office of Defense Programs issued a safety information letter, SIL 96-03, “Electric Shock.” This publication describes nine representative events chosen to illustrate the hazards of unexpected exposure to electricity. DOE facility managers, facility representatives, and contractor facility managers should continue to emphasize the dangers and life-threatening characteristics of uncontrolled electricity.

[6] OEAF engineers developed data based on a review of 794 occurrences from October 1, 1990, through March 31, 1998.

- DOE-STD-1073-93-Pt.1 and –Pt.2*, Guide for Operational Configuration Management Programs, Including the Adjunct Programs of Design Reconstitution and Material Condition and Aging Management*, provides guidelines and good practices for an operational configuration management program including change control and document control.

- The *Hazard and Barrier Analysis Guide*, developed by OEAF, discusses barriers that provide controls over hazards associated with a job. Barriers may be physical barriers, procedural or administrative barriers, or human action. The reliability of barriers is important in preventing undesirable events such as shocks. The reliability of a barrier is determined by its ability to resist failure. Barriers can be imposed in parallel to provide defense-in-depth and to increase the margin of safety. The *Hazard and Barrier Analysis Guide* provides a detailed analysis for selecting optimum barriers, including a matrix that displays the effectiveness of different barriers in protecting against some common hazards.

A copy of the *Hazard and Barrier Analysis Guide* is available by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. A copy can also be found at URL http://tis.eh.doe.gov:80/web/oeaf/tools/hazbar.pdf.

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